

Estimating Soil/Dust Ingestion through the Blood to Soil/Dust Lead Relationship

AEHS Foundation

24th Annual International Conference

March 18, 2014

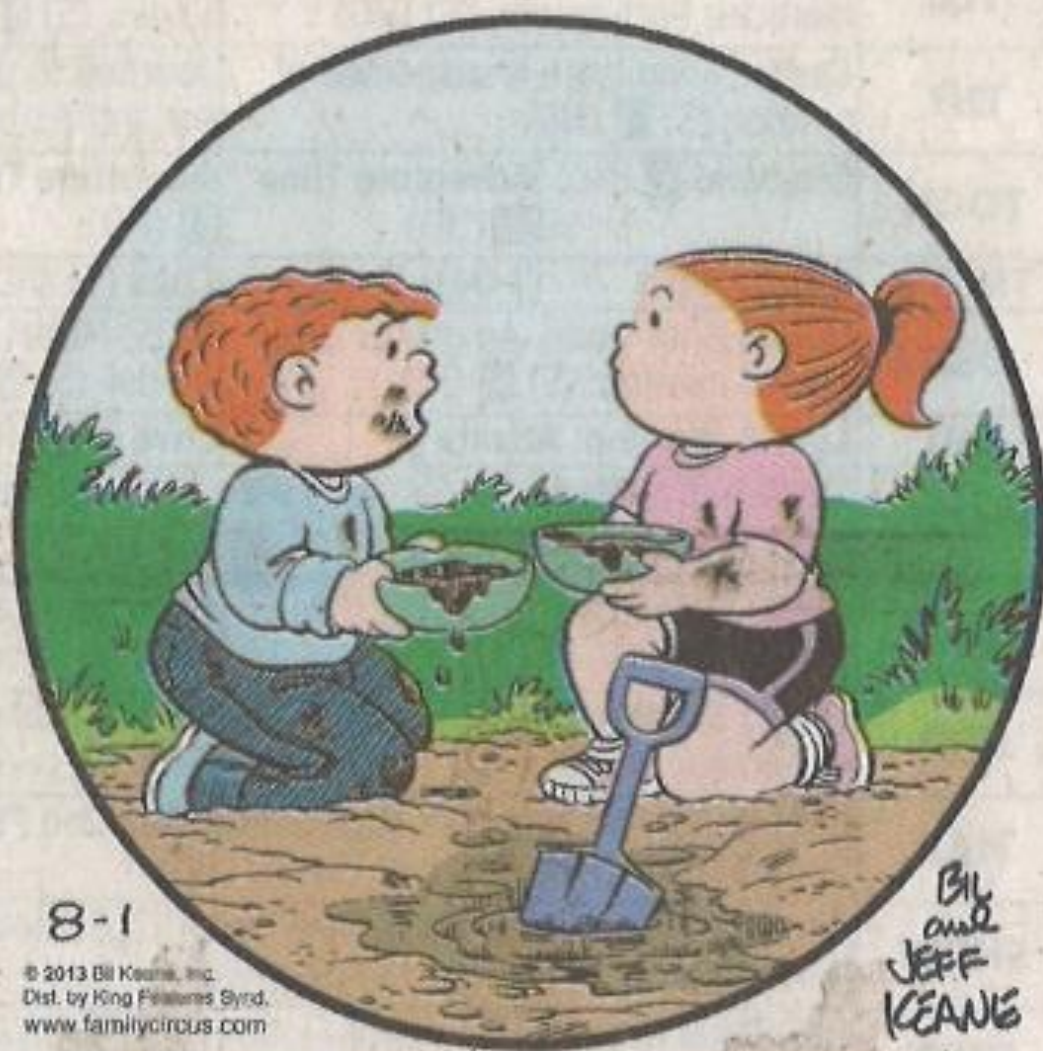
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The Family Circus

Bil Keane



8-1

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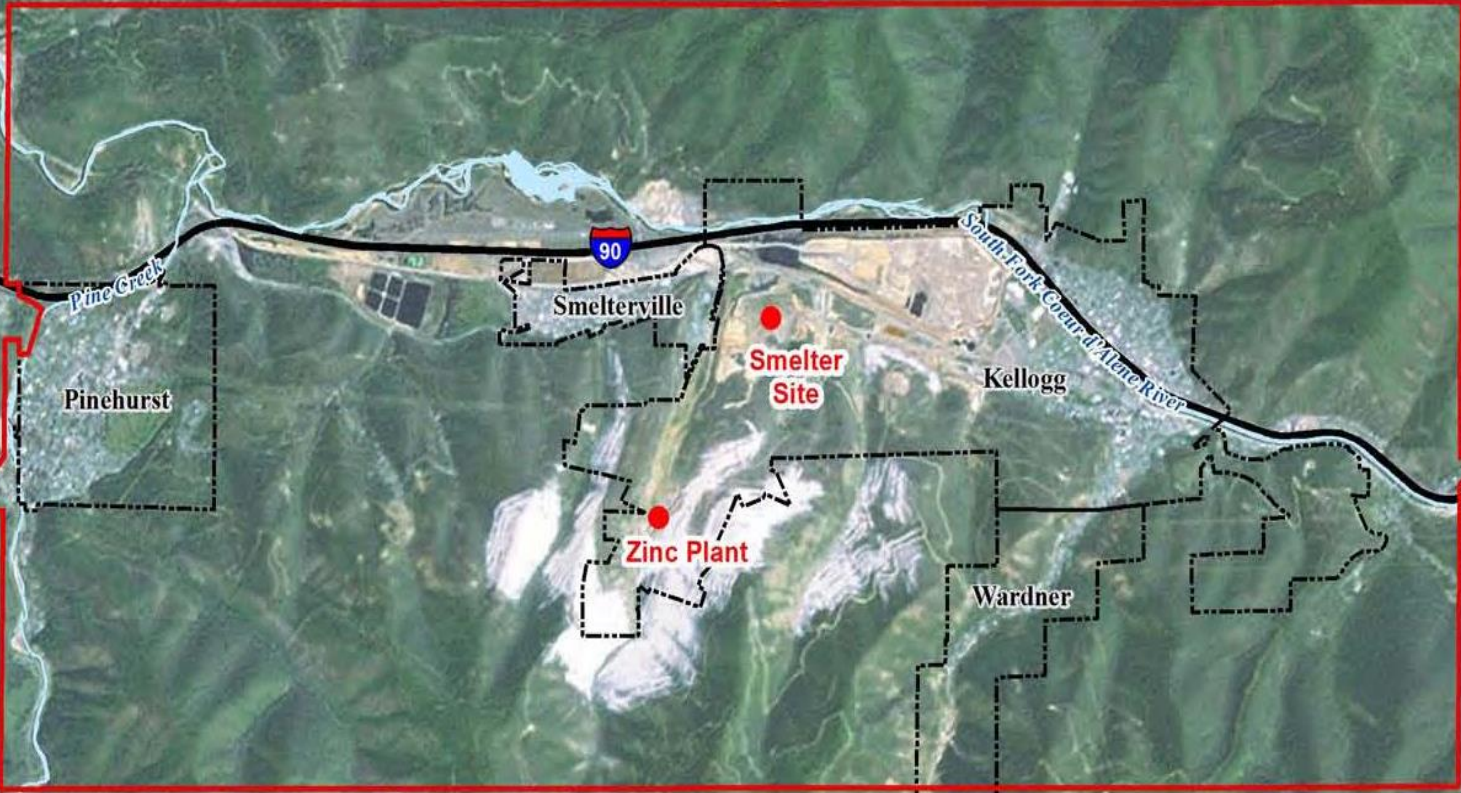
BIL
and
JEFF
KEANE

**"This mud doesn't taste very good.
I think you forgot to add salt."**

Presentation Outline

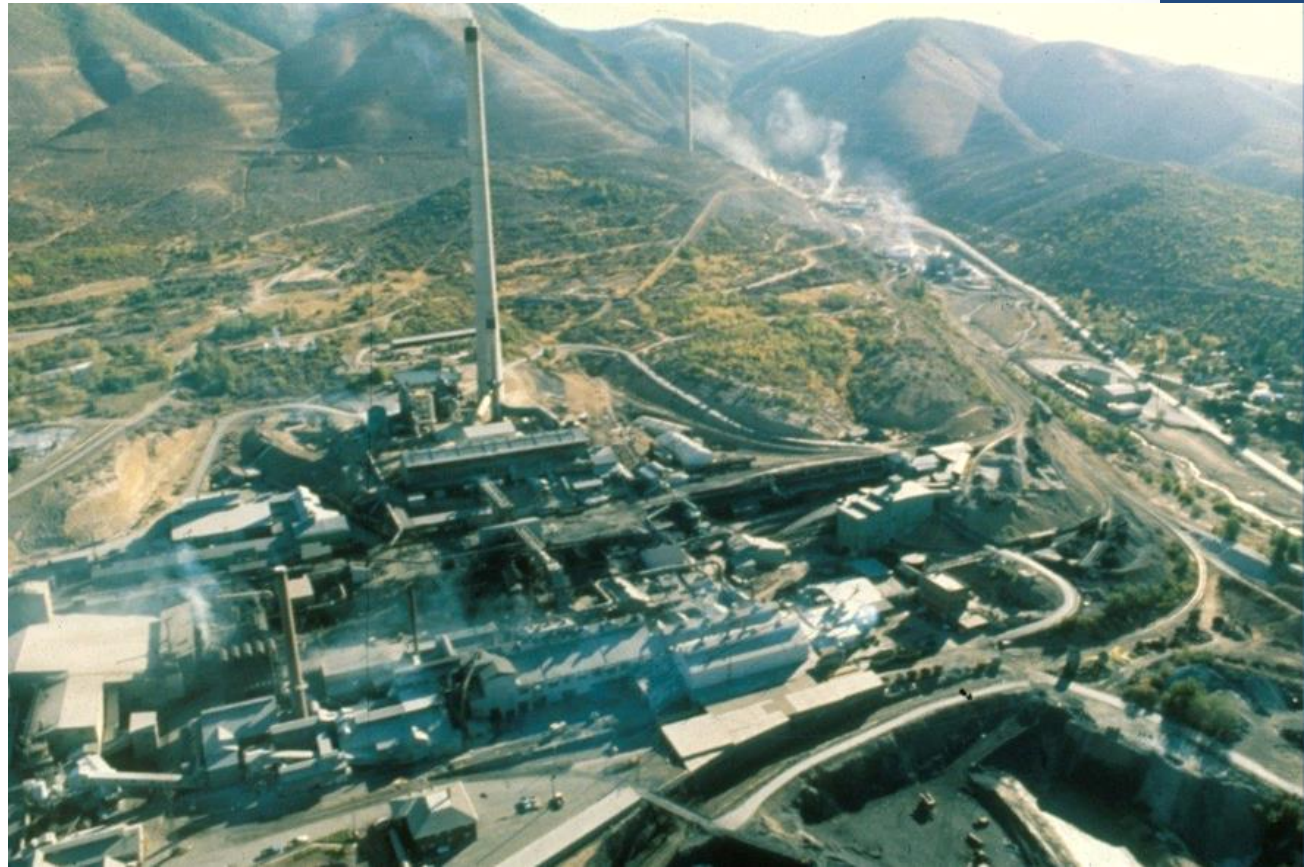
- Bunker Hill Superfund Site Background and History
- Approach
- Methods and Results
- Conclusions

This map was produced using information obtained from several different sources that have not been independently verified. These sources have also not provided information on the precision and accuracy of the data. Information on this map is not a substitute for survey data.



Bunker Hill Company Mining and Smelter Complex, 1917-1981

- Produced $\frac{1}{3}$ the nation's lead, $\frac{1}{2}$ the silver, $\frac{1}{4}$ zinc
- Idaho's largest employer



Waste and Air Pollution Producers

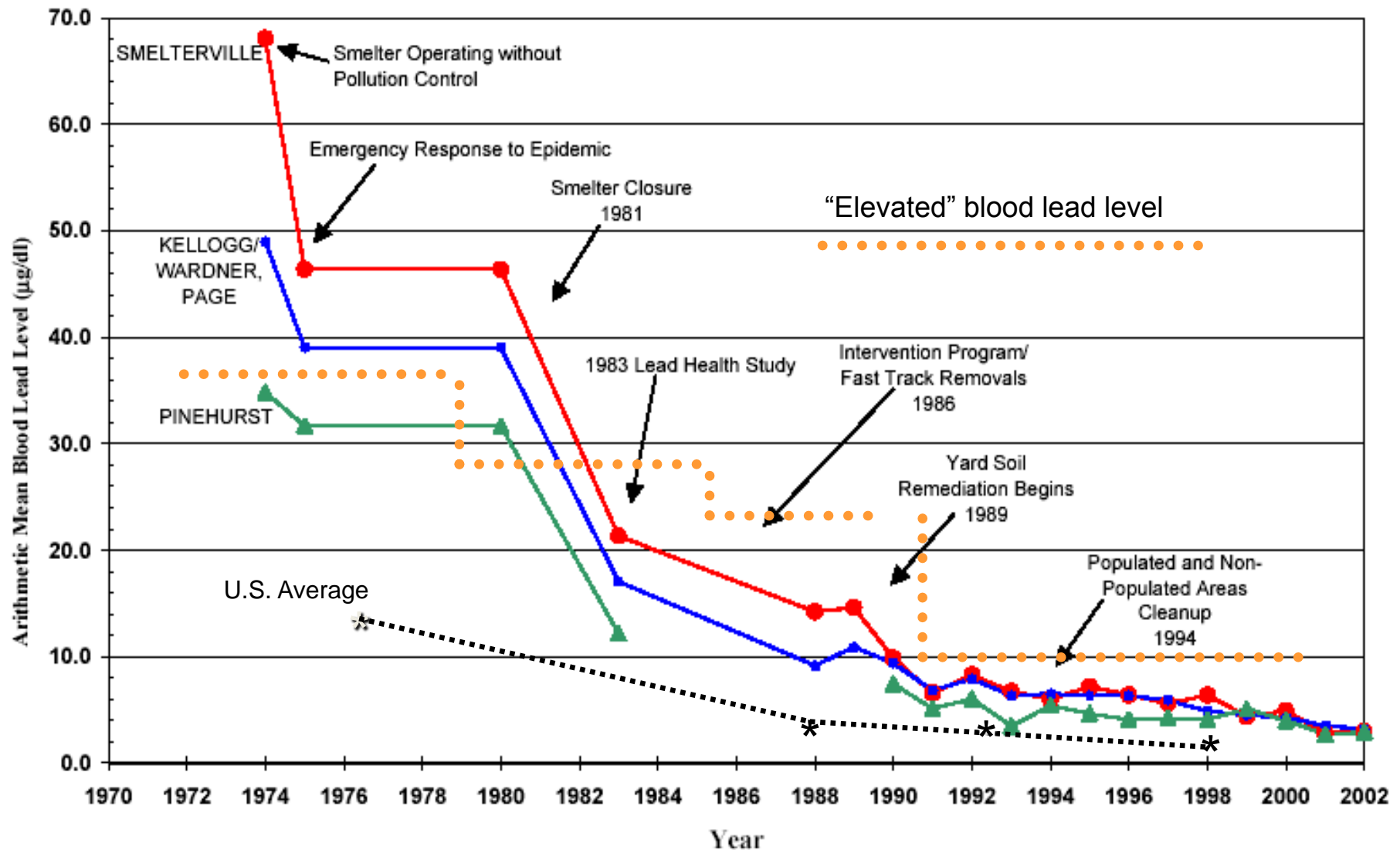
- Lead Smelter
- Zinc Plant
- Mills
- Mines
- Support Facilities
- Railroad



In 1973, one of the worst child lead poisoning events in U.S. history occurred at the Bunker Hill Smelter.



Blood Lead Levels Bunker Hill Site 1974-2002



Biological Monitoring

- 1984 – voluntary fixed-site screening was met with low participation
- 1985 – door-to-door solicitation strategy to secure blood samples
- 1988 – payment for participation was initiated for blood samples
- 2003 – payment for participation ended, blood lead remediation action objectives met
- **PUBLIC HEALTH SERVICES CONTINUE TODAY**



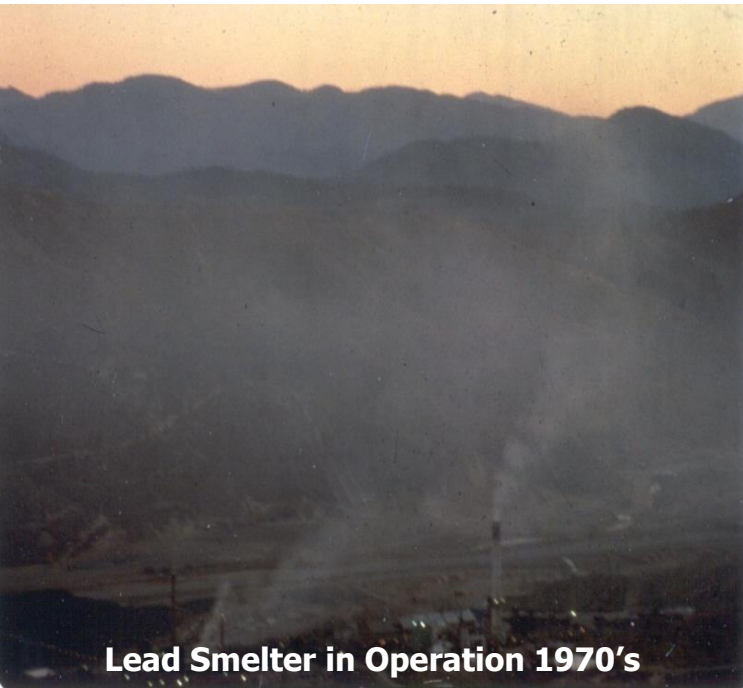
Intervention and Source Control

Objective:

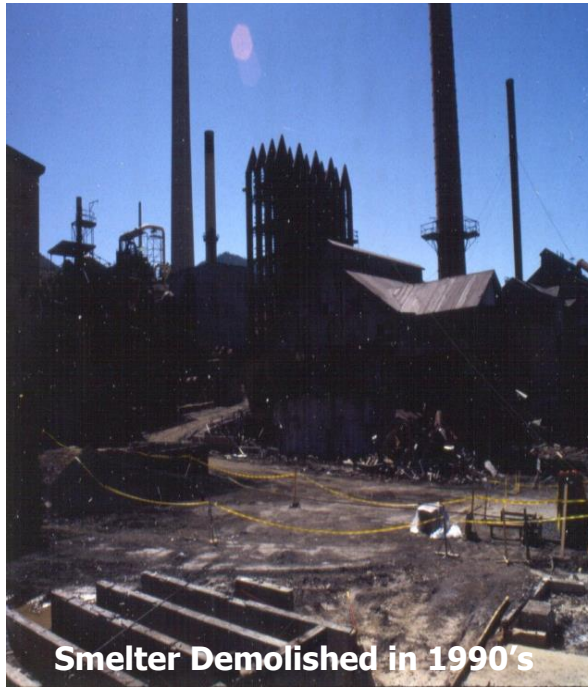
- Minimize lead absorption while source control actions were underway
 - In-home intervention
 - Public awareness
 - Outreach and education



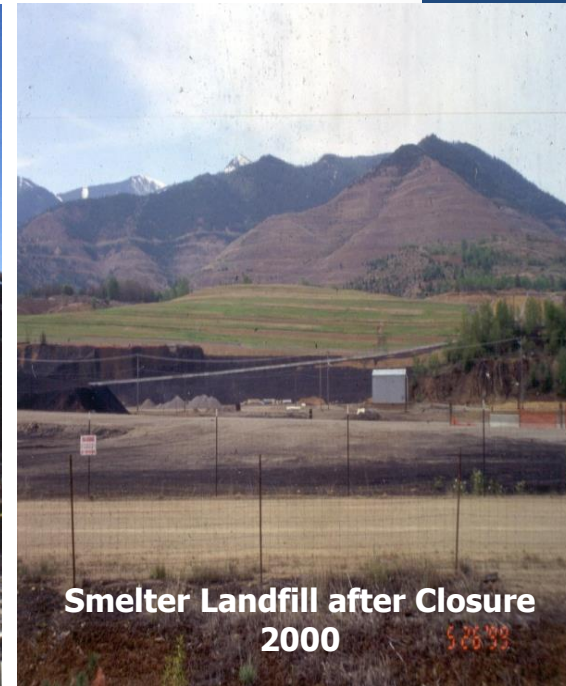
Industrial Complex Demolished and Disposed of in High Level Waste Repository



Lead Smelter in Operation 1970's



Smelter Demolished in 1990's



**Smelter Landfill after Closure
2000**

Common Area Cleanups

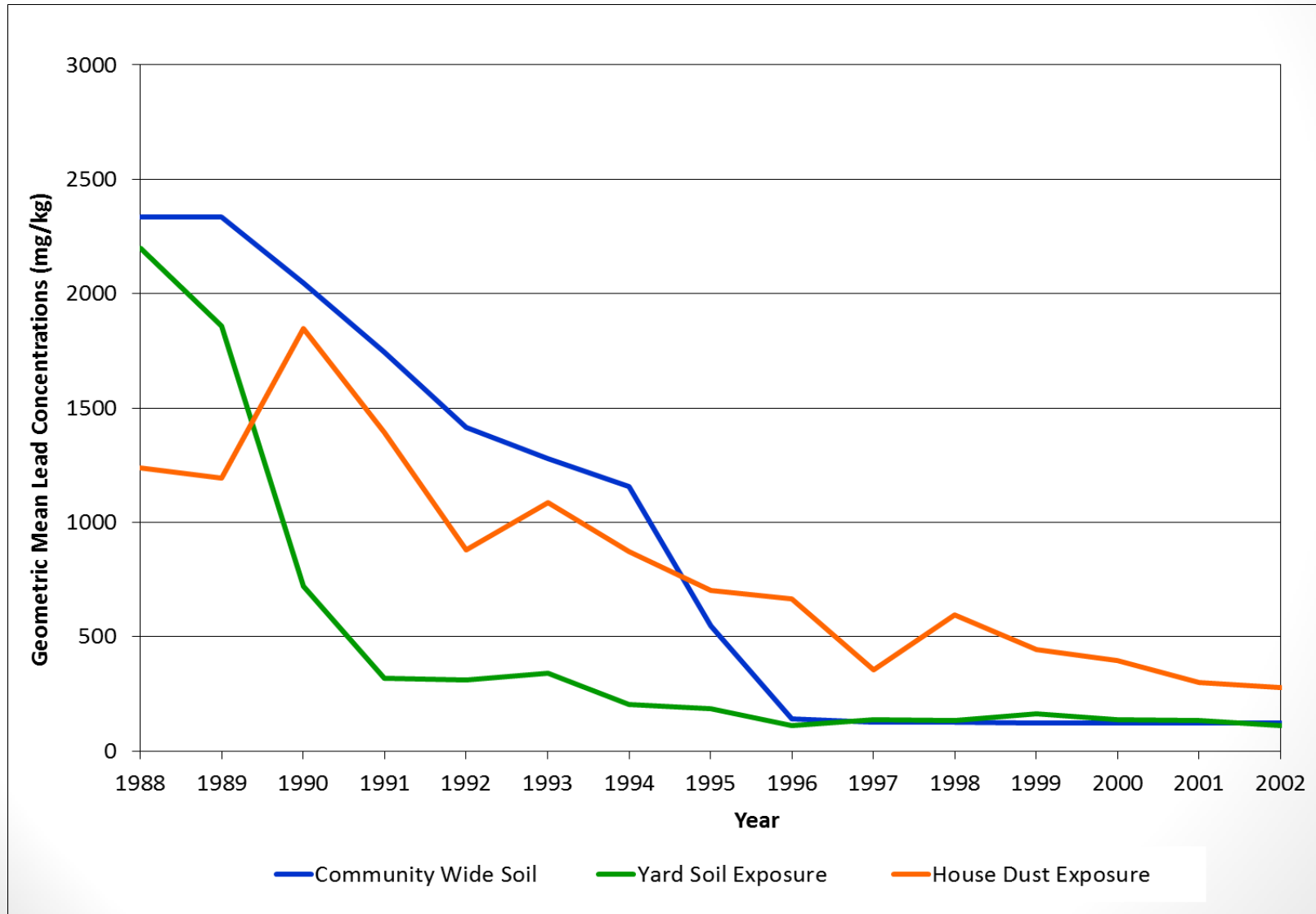
Parks, Playgrounds, Schools, Daycares



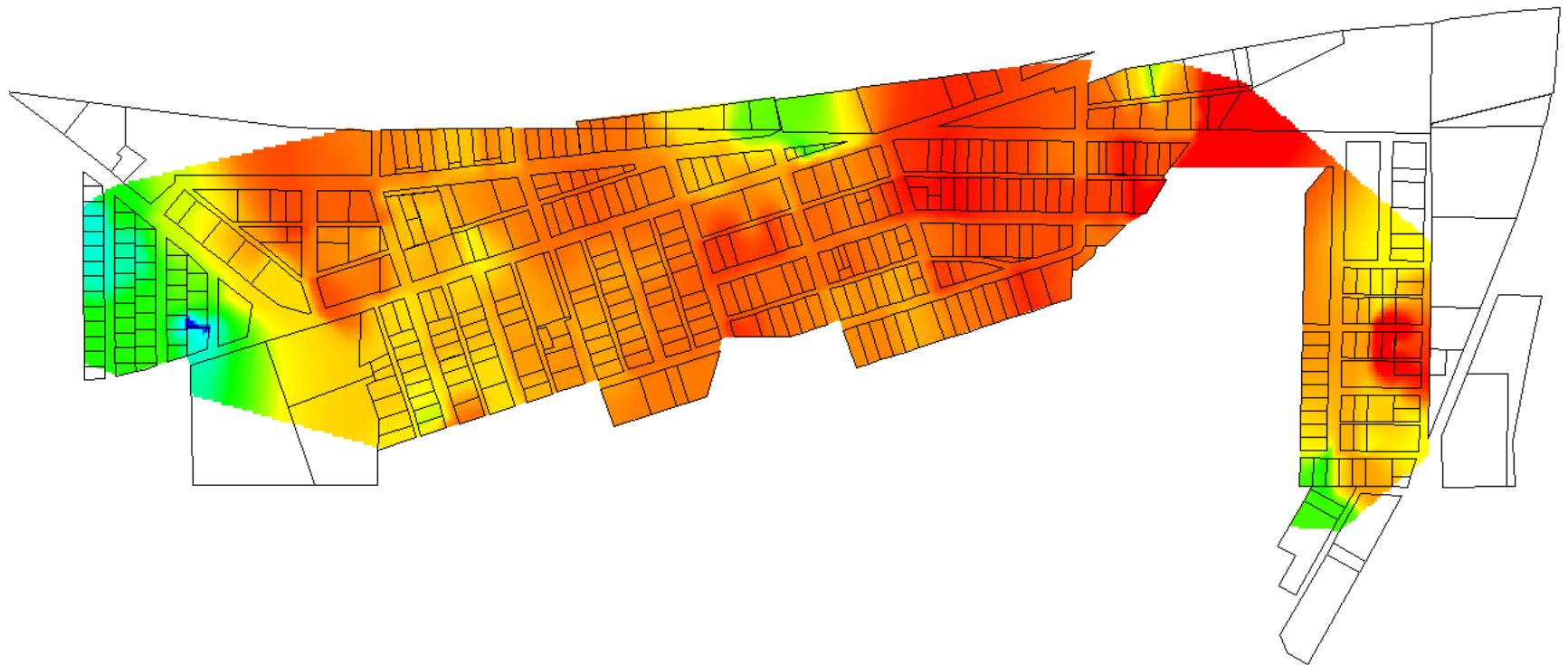
Residential Property Cleanups



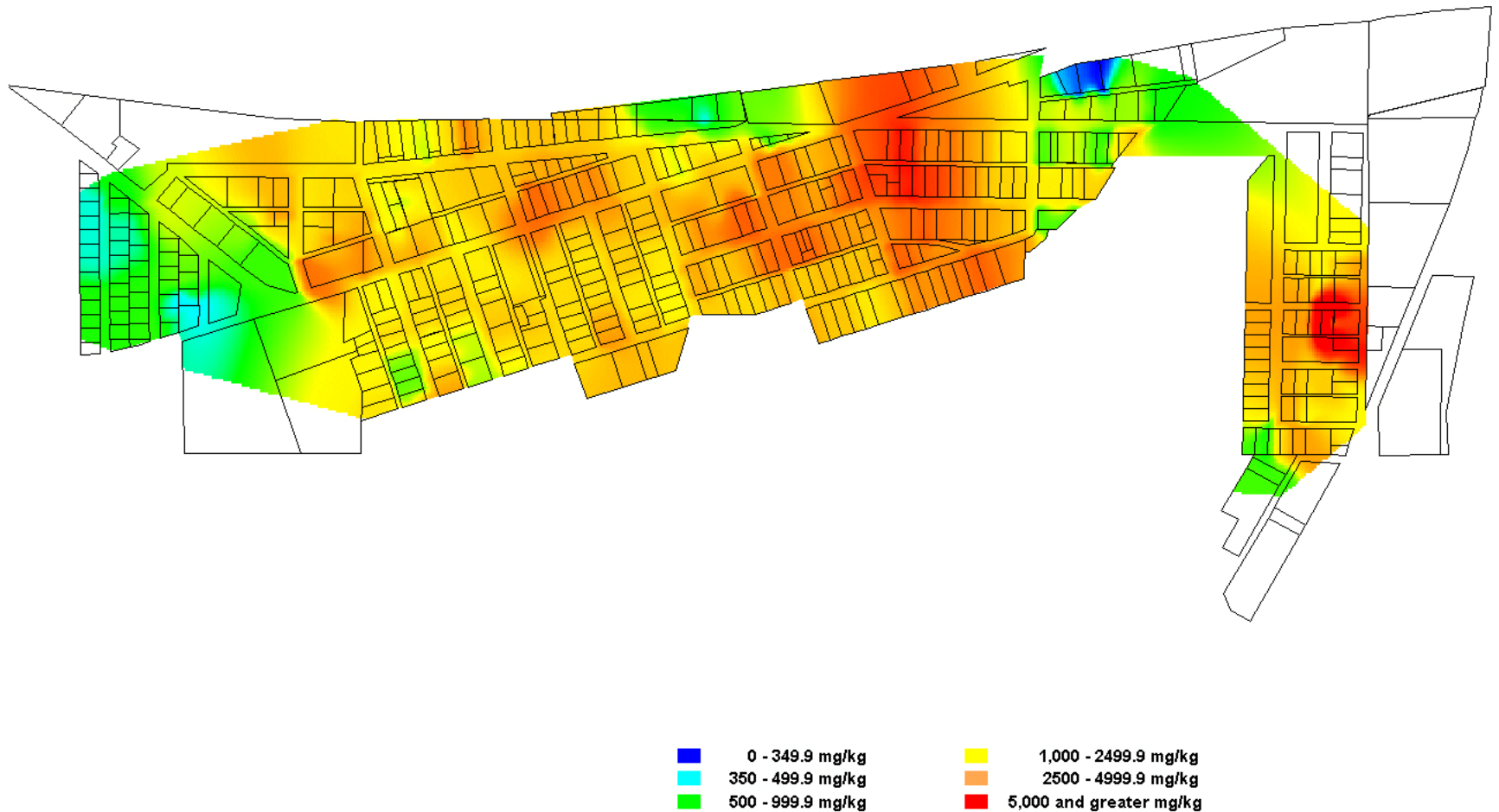
Yard Soil and House Dust Lead Concentrations Smelterville, 1988-2002



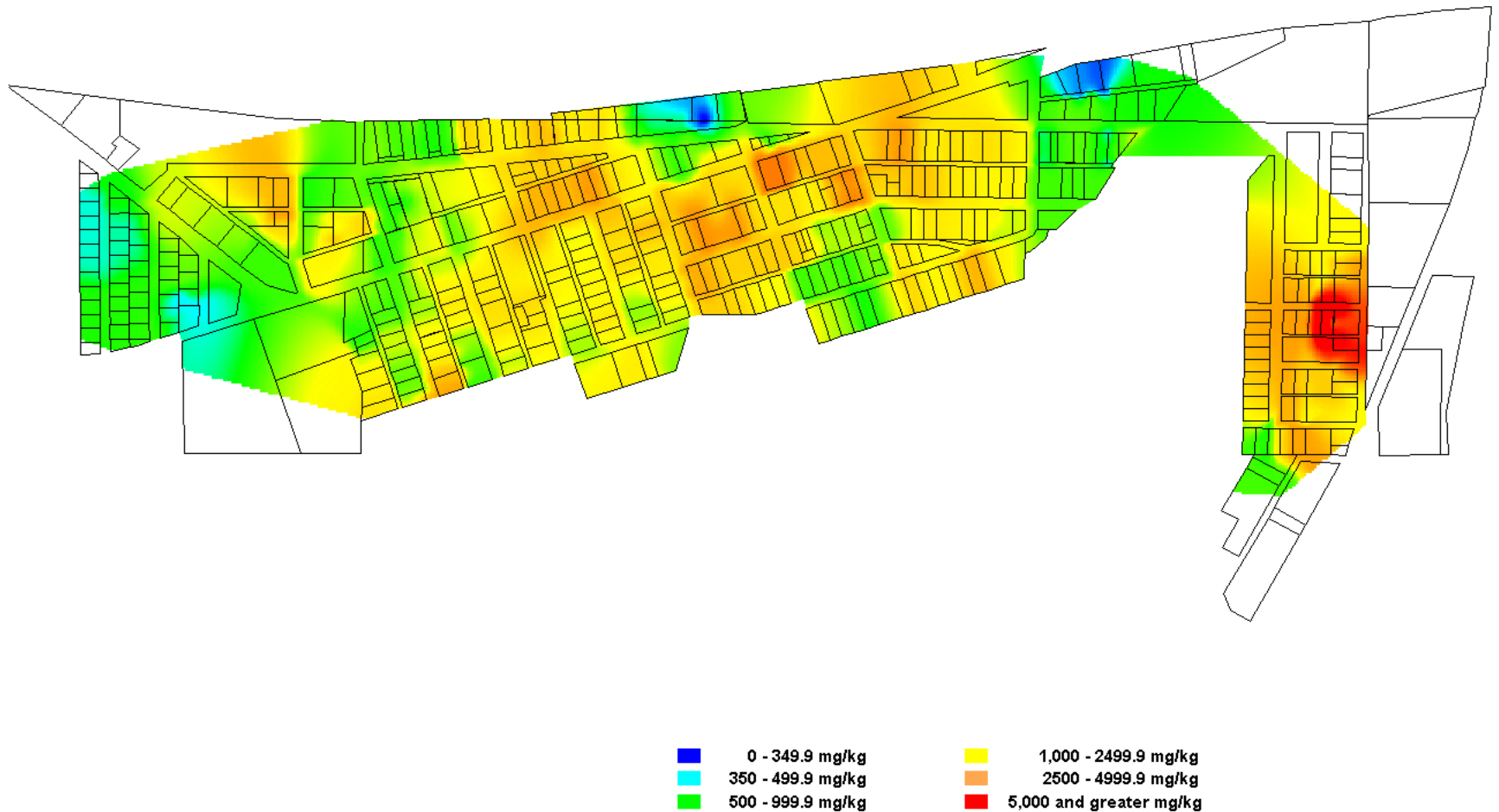
Neighborhood Soil Lead Concentration Smelterville 1989



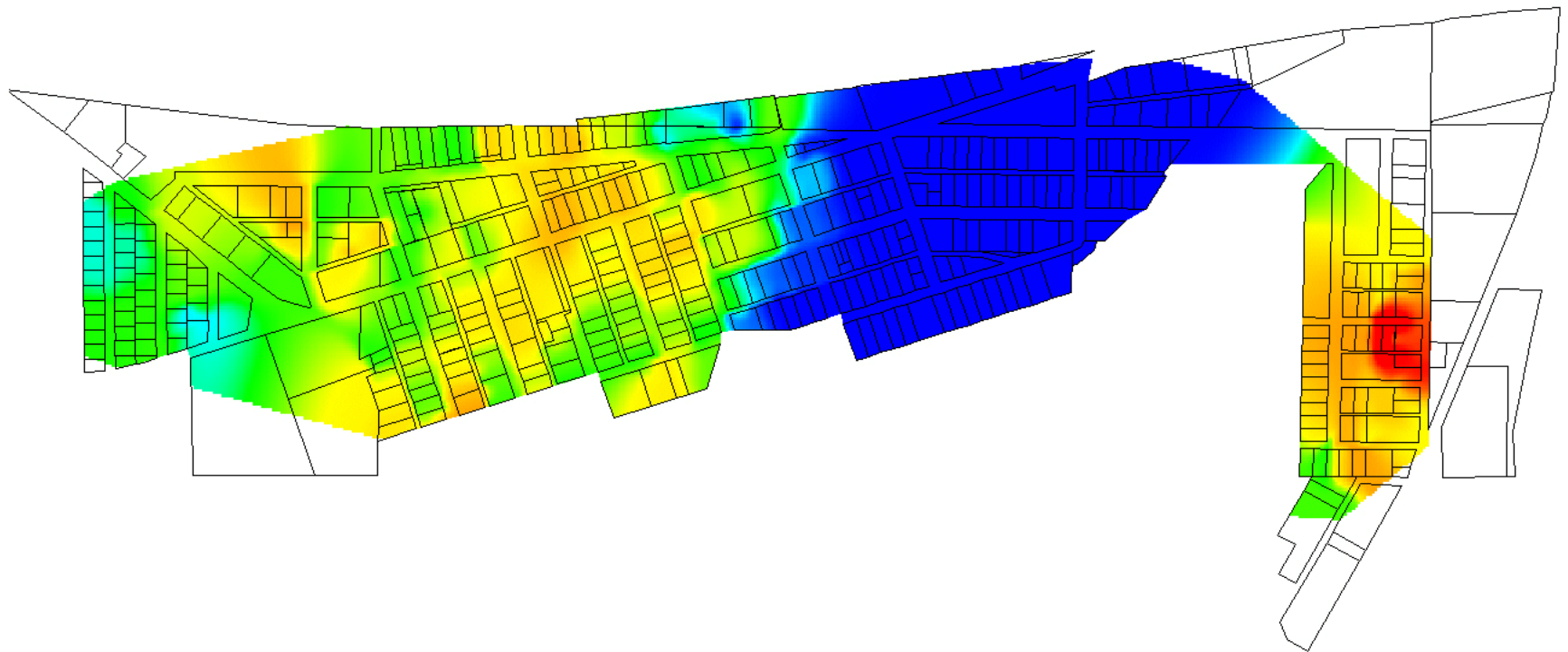
Neighborhood Soil Lead Concentration Smelterville 1991



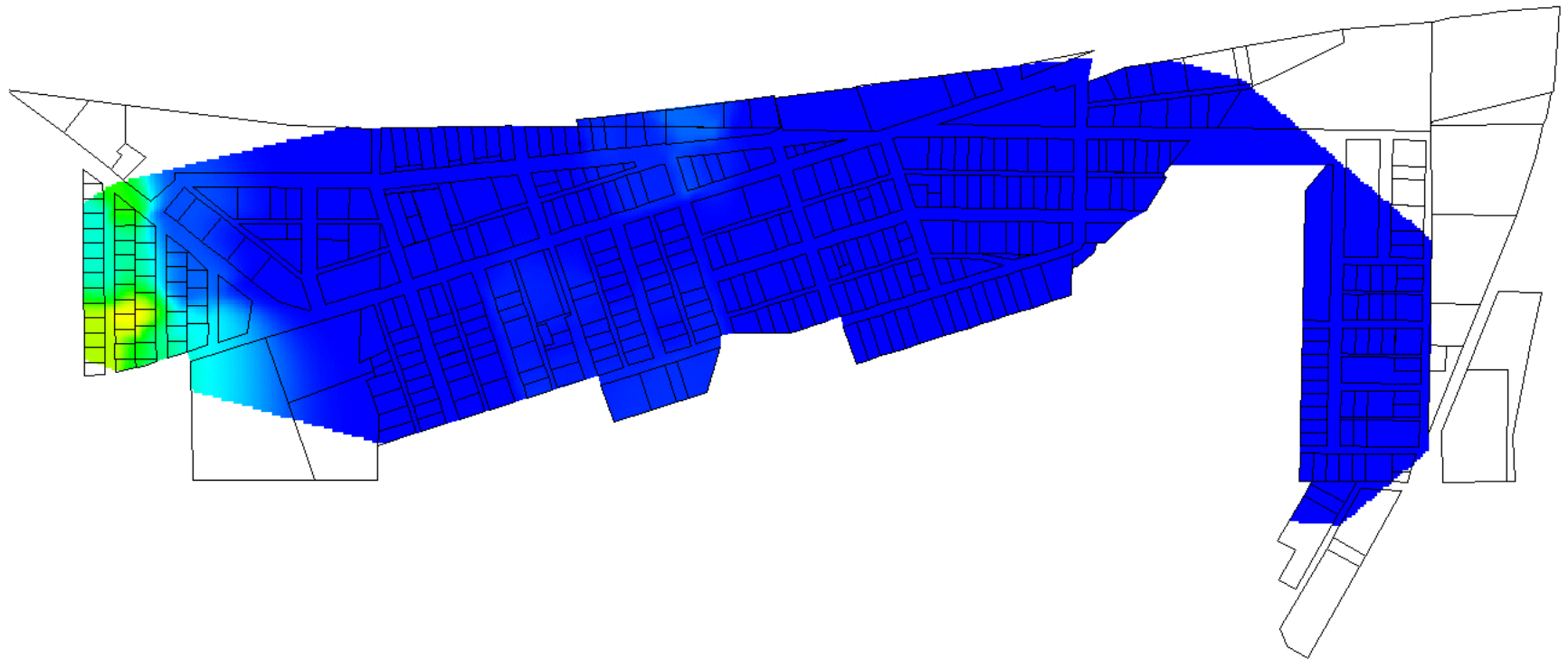
Neighborhood Soil Lead Concentration Smelterville 1993



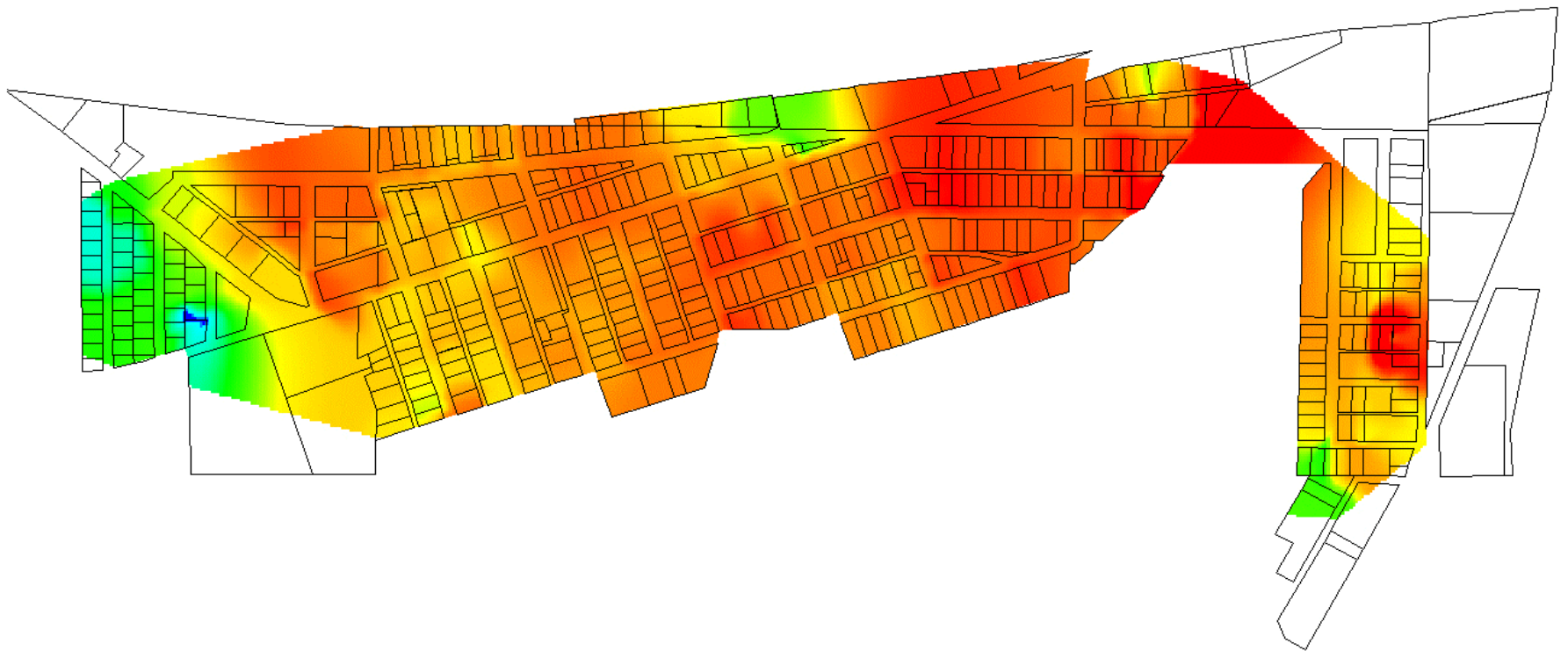
Neighborhood Soil Lead Concentration Smelterville 1995



Neighborhood Soil Lead Concentration Smelterville 1997



Subsurface Lead Contamination Below 1 Foot Smelterville after Remediation



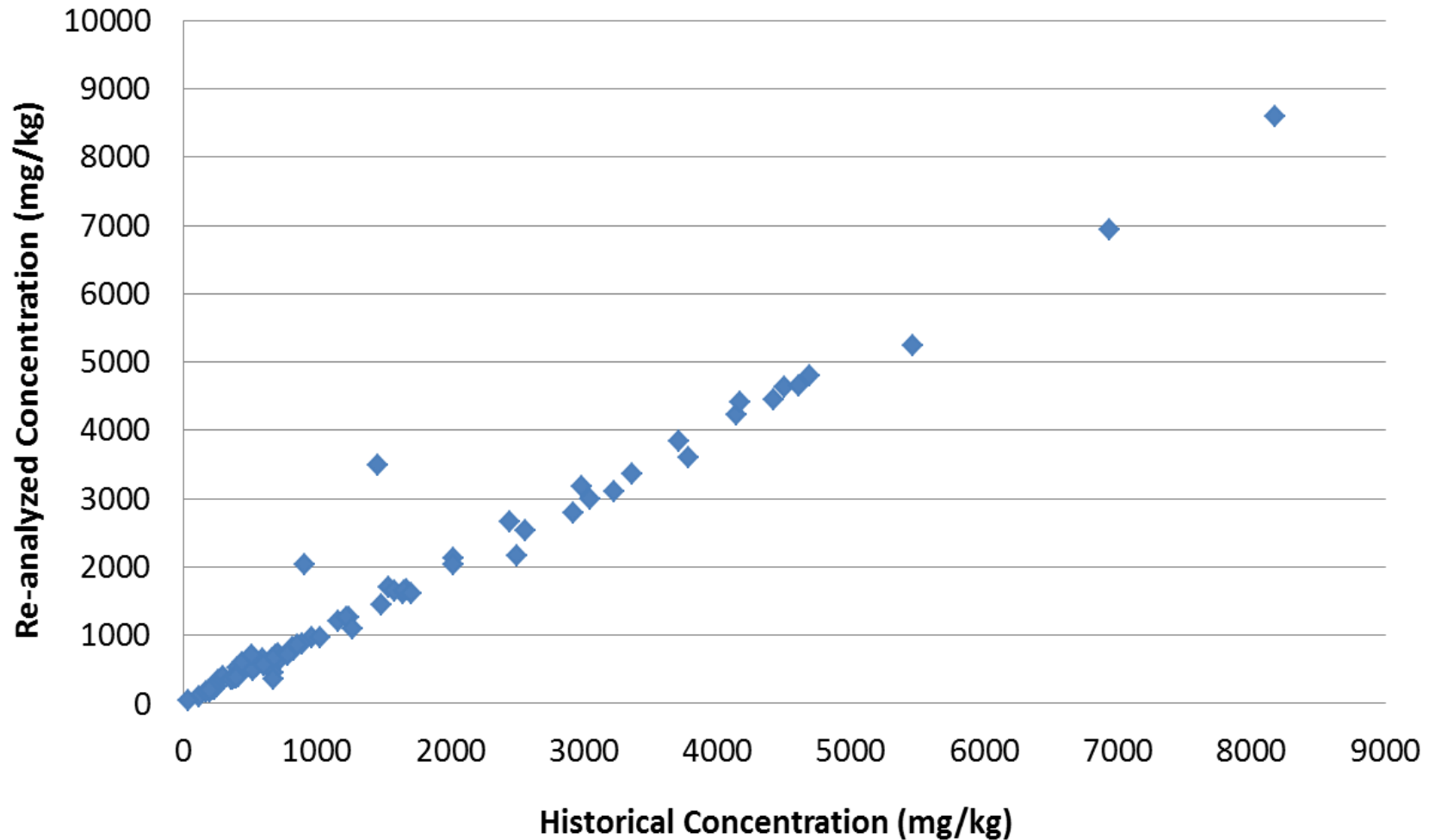
Data Collected in Combined Intervention / Remediation Program

- Spanning 15 years
- >5,000 Blood Lead Observations
- Paired with:
 - Residential Soil Lead Levels
 - House Dust Lead Levels
 - Community Environmental Measurements
 - Demographic, Housing, Health, Socio-economic Indices

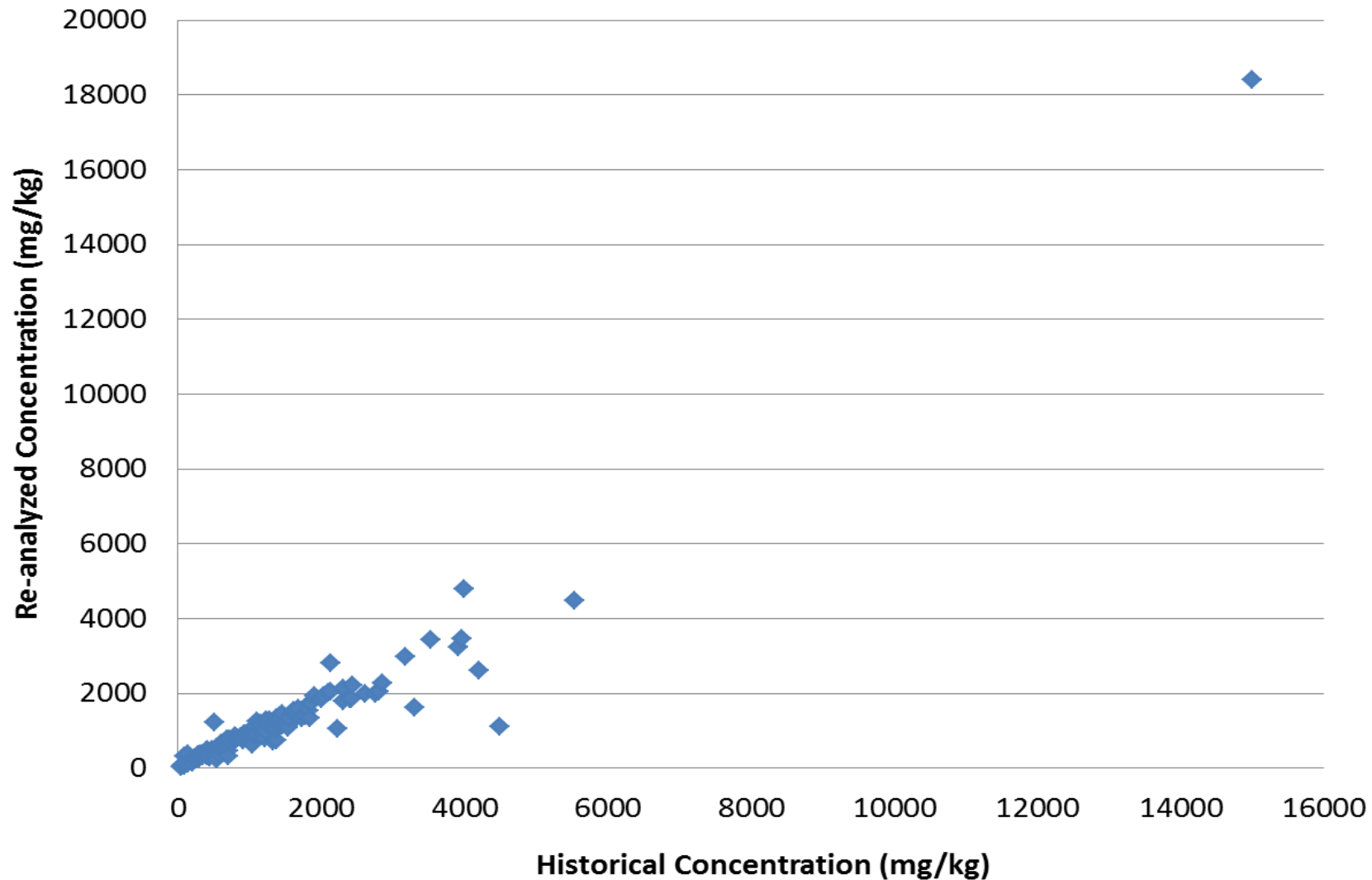
Approach

- Select archived soil and dust samples for laboratory analysis
 - Total lead (EPA Method 6010b)
 - *in vitro* bioaccessibility, indicator of *in vivo* relative bioavailability
- Compare new total lead results to historical results
- Calculate age-specific ingestion rates through total lead uptake
 - Soil/dust partition model applied at Bunker Hill (40:30:30)
 - Structural equation modeling (SEM)
- Use ingestion rates and bioavailability data in the Integrated Exposure Uptake Biokinetic Model (IEUBK) for best fit

Comparable & Representative – Soil Lead



Comparable & Representative – Dust Lead



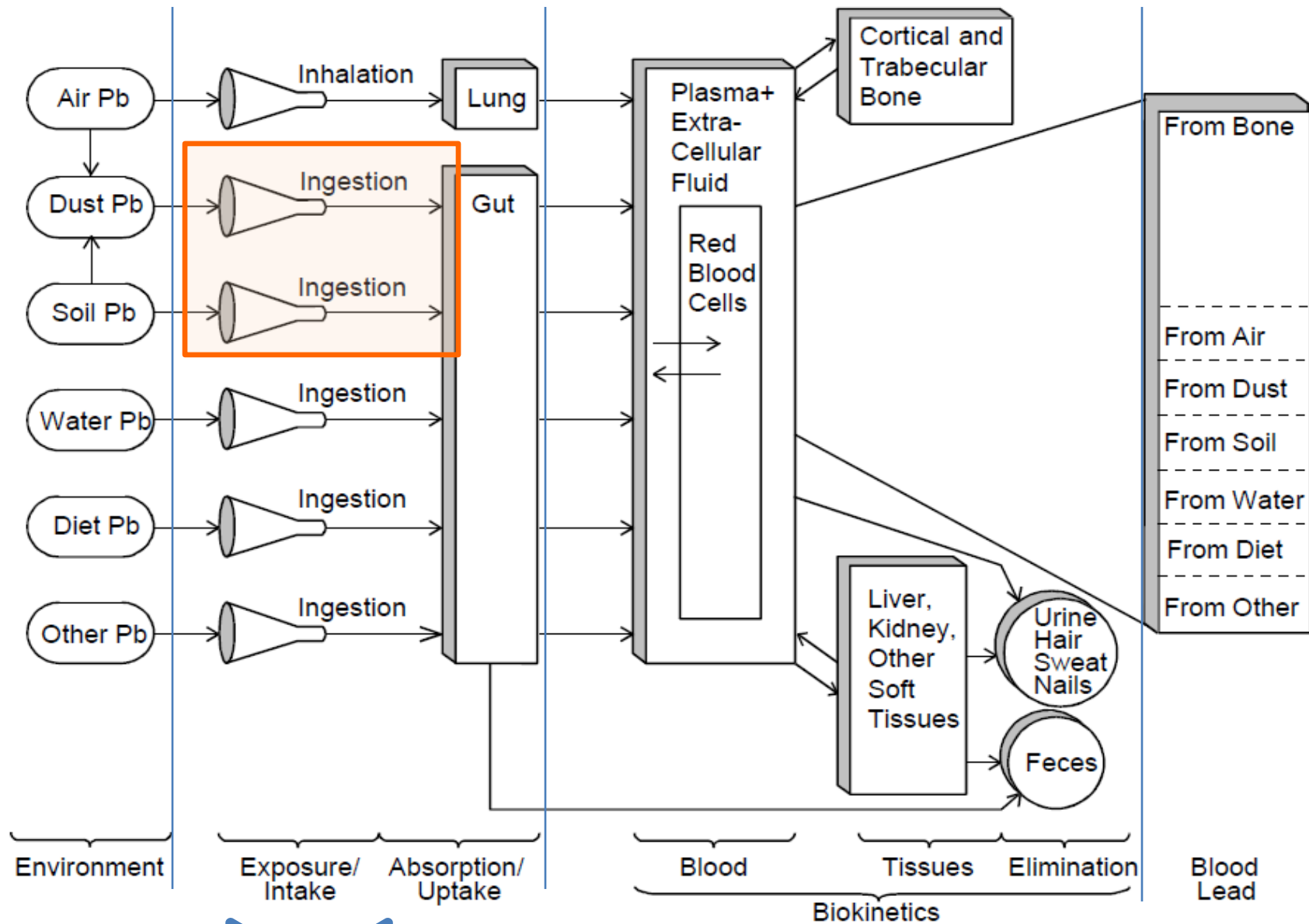
Absolute Bioavailability Results

City	Soil		House Dust	
	Number of Samples	Average Bioavailability	Number of Samples	Average Bioavailability
Kellogg	24	0.34	66	0.28
Page	7	0.33	12	0.27
Pinehurst	33	0.32	74	0.28
Smelterville	8	0.39	36	0.30
Wardner	1	0.30	4	0.27
Total	73	0.33	192	0.28

Ingestion Calculations - Exposure Pathways

- **Bunker Hill Model - 40:30:30 partition**
 - 40% from house dust
 - 60% from residential soil comprised of:
 - 30% from home yard soil
 - 30% from community-wide soils
- **IEUBK Default Model - 55:45 partition**
 - 55% from house dust
 - 45% from residential yard soils
 - no contribution from community soils

IEUBK Model



Ingestion Calculations – 40:30:30

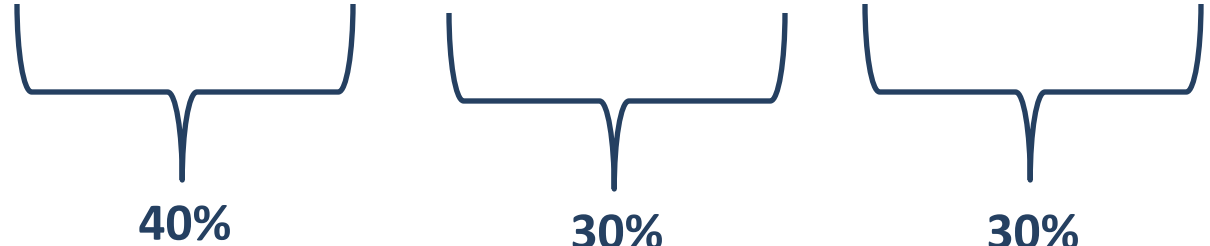
1. $UP_{total} = BLPb / CR^{-1}$

where

- UP_{total} = total lead uptake, $\mu\text{g}/\text{day}$
- CR^{-1} = Harley Kneip age-specific blood lead response coefficient, unitless
- $BLPb$ = individual blood lead concentration, $\mu\text{g}/\text{dL}$

2. $UP_{total} = UP_{air} + UP_{diet} + UP_{water} + UP_{sd}$

Ingestion Calculations – 40:30:30

$$3. \quad UP_{sd} = (C_d * IR_d * ABS_d) + (C_{ys} * IR_{ys} * ABS_{ys}) + (C_{cs} * IR_{cs} * ABS_{cs})$$


40% 30% 30%

where

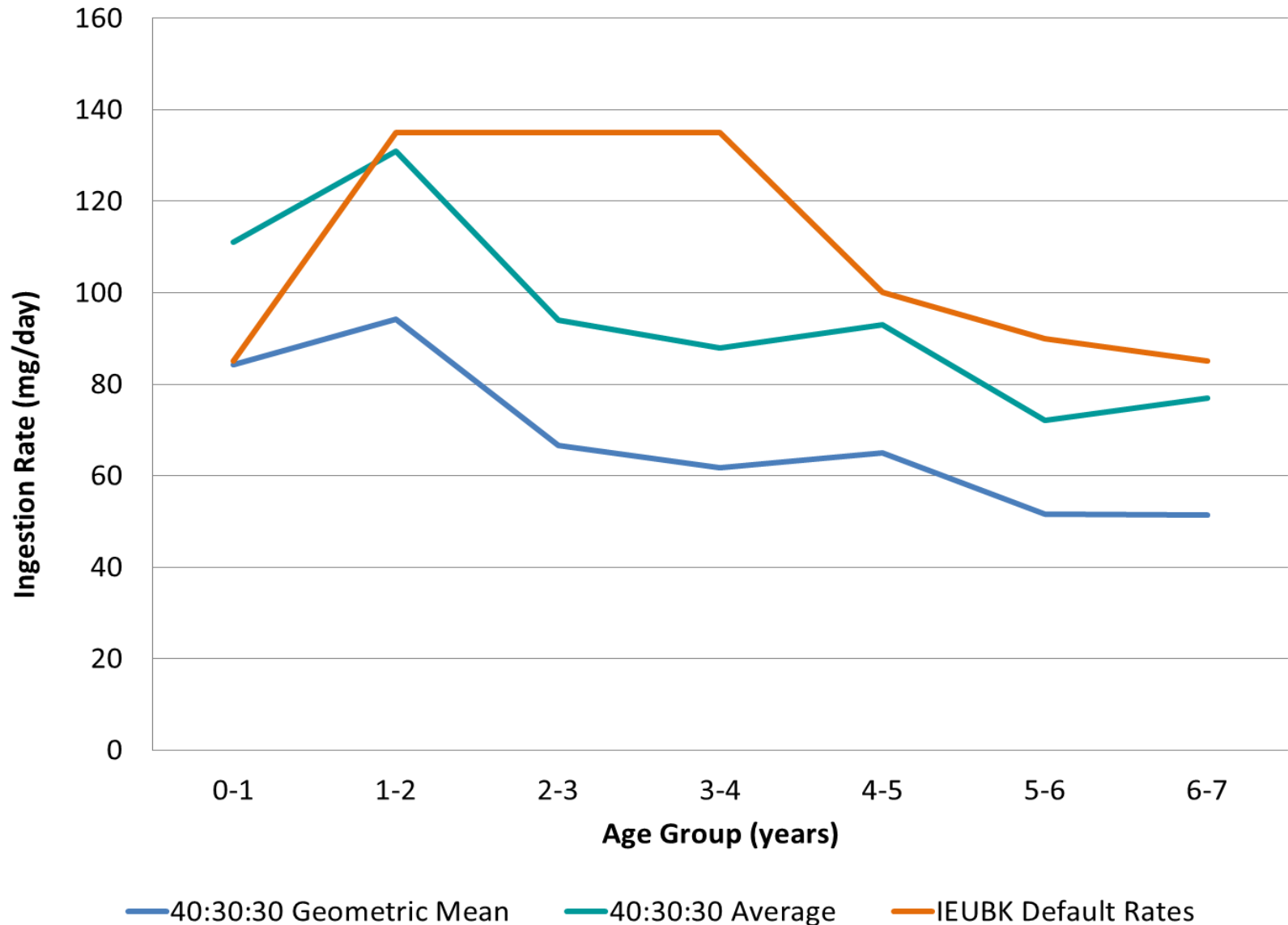
- UP_{sd} = combined lead uptake from soil and dust, $\mu\text{g}/\text{day}$
- C_i = lead concentration, mg/kg
- IR_i = ingestion rate, mg/day
- ABS_i = bioavailability, unitless

Ingestion Calculations – 40:30:30

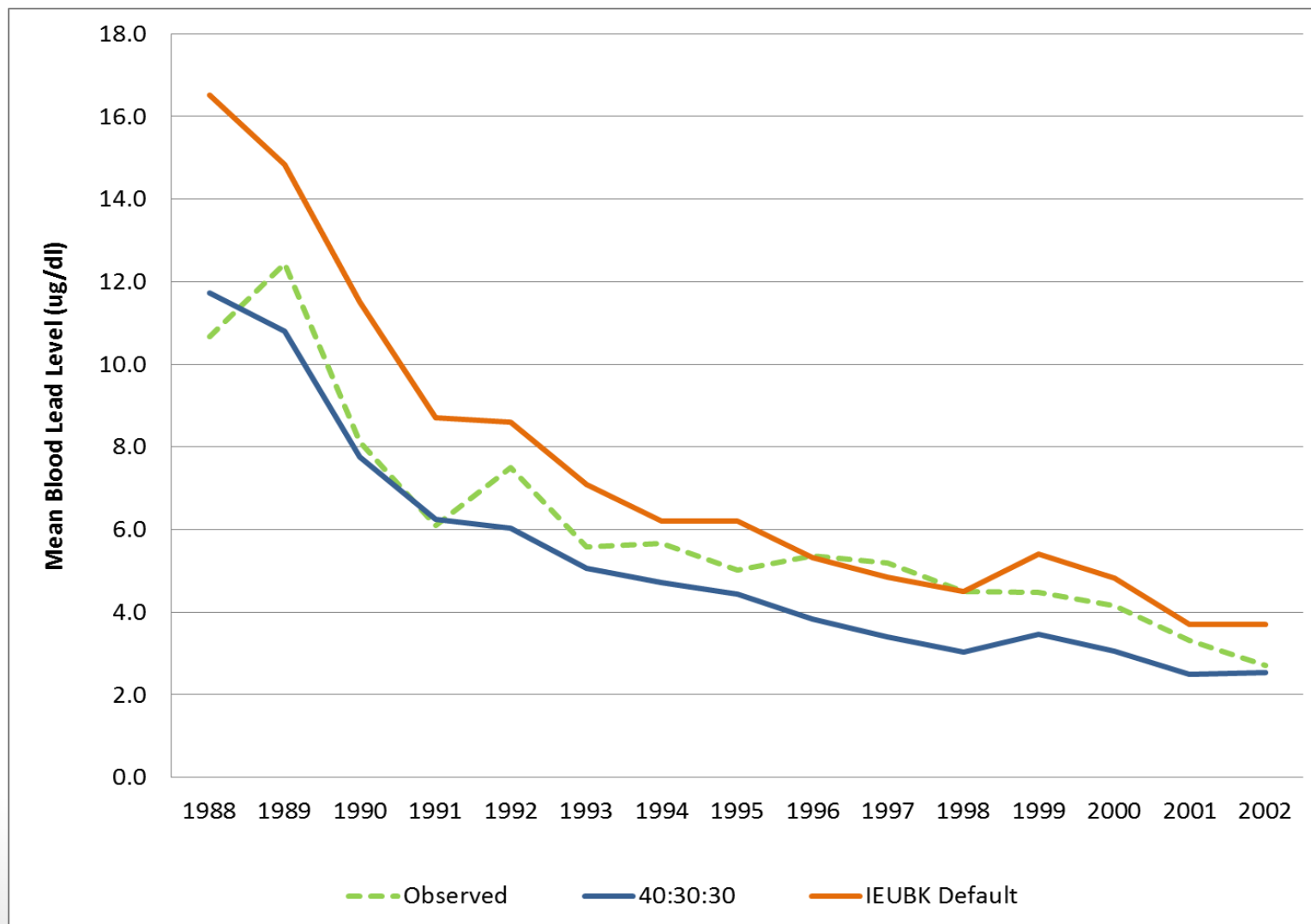
$$IR_{sd} = 1000 \times \left[\frac{UP_{sd}}{(C_d \times 0.4 \times ABS_d) + (C_{ys} \times 0.3 \times ABS_{ys}) + (C_{cs} \times 0.3 \times ABS_{cs})} \right]$$



40:30:30 Calculated Ingestion Rates



IEUBK - Observed vs. Predicted Mean Blood Lead Levels (40:30:30 & IEUBK Default)



Ingestion Calculations – SEM

- SEM regression using lead uptake (UP_{sd})
 - SAS v8 - PROC GLM and PROC CALIS
- Several iterations due to various combinations of neighborhood means (200, 500, and 1000 feet radii) and community means
- Successive variables were added to the model by
 - Chi-Square criteria for fit ($p > 0.05$)
 - Overall improvement in Goodness of Fit statistics
- Parameter estimates = ingestion and partition

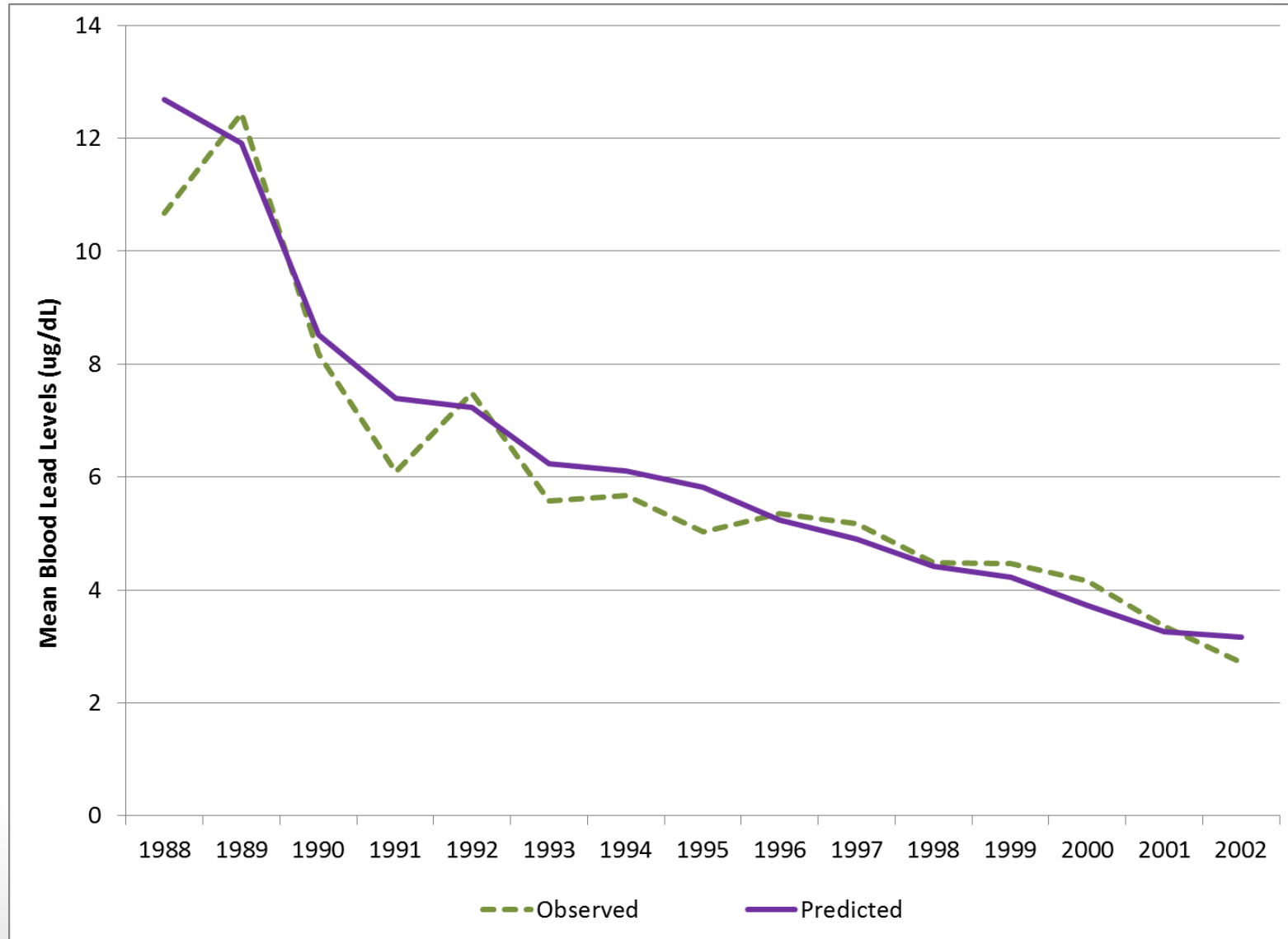
SEM Calculated Ingestion Rates

Age (years)	40:30:30 Ingestion Rate (mg/day)	SEM Ingestion Rate (mg/day)	IEUBK Ingestion Rate (mg/day)
0-1	84	82	85
1-2	94	90	135
2-3	67	60	135
3-4	62		135
4-5	65		100
5-6	52	58	90
6-7	51		85
7-8	50		--
8-9	56		--
9-10	58		--
Total 0-7	68	67	109

SEM Exposure Pathways Results

- 45%–50% house dust
 - 25%–28% yard soil
 - 14%–18% neighborhood soil (within 500 feet of the home)
 - 7%–11% community soils
-
- depending on model form and variable definitions

IEUBK – Observed vs. Predicted Mean Blood Lead Levels (SEM)



Conclusions

- Calculated soil/dust ingestion rates:
 - 39% lower than recommended IEUBK ingestion rates
 - Reflect residential exposures, including house dust, yard soils, neighborhood and community soils
- Exposure pathways, or partitions, impact IEUBK Model predictability
- Do not significantly impact the Bunker Hill cleanup

Acknowledgements:

- EPA and the Regional Applied Research Effort funding
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- TerraGraphics Environmental Engineering staff
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Questions?